THE MATURATION DIVISIONS IN ASCARIS INCURVA.

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In the following preliminary account of the spermatogenesis and ovogenesis of a nematode, *Ascaris incurva* Rud., it is intended to call particular attention to a remarkable XY-group that forms the extreme case thus far observed. The X-group consists of no less than eight components of which one is a vestigial microsome, while the Y is represented by but a single chromosome. The nearest approach to this case is that described by Edwards, '10, for *Ascaris lumbricoides*, where in the heteropolar mitosis the X-element is found to consist of five components unmated by a Y. The extreme example hitherto described in which a Y exists is that of *Acholla multispinosa* described by Payne, '10, in which case five X-components are opposed by one Y, but here the Y is equal to or larger in mass than the combined X-elements.

Ascaris incurva is a parasite found in the stomach of the swordfish, *Xiphias gladius* L. The material was collected at Woods Hole during the summer of 1913, and most of this thus far studied was fixed in strong Flemming's or Gilson-Carnoy's fluid.

A study of the spermatogonial cells has proved unsatisfactory as the chromosomes are closely massed and the cytoplasm stains deeply. Counts vary from 33 to 35. Fig. 1, showing a cell somewhat over-extracted as is desirable to give the necessary contrast, gives a count of 35 chromosomes including the microsome.

During the growth stages a part of the chromatin is massed in a large irregular karyosome. Late prophase or metaphase figures of the first spermatocyte division show 21 chromosomes or 22 if the Y is widely separated from its mate in the X-group (Fig. 2).

Early anaphase figures of the first spermatocyte division show most clearly the unequal nature of the separation of the chromosome groups. Thirteen autosomes lying at or near the periphery

of the plate divide equally, thus forming two anaphase plates of thirteen chromosomes, typically arranged in a ring except that at a point of one daughter plate a gap is observed, opposite which in the other plate is a fourteenth chromosome (Figs. 4 and 6). There remain eight chromosomes lagging in the center of the spindle and arranged in a characteristic plate consisting of six chromosomes of the average size, the microsome and a larger long chromosome arranged in an approximately oval or circular plate with the long chromosome projecting from the periphery (Figs. 5 and 8). As the daughter plates separate, this peculiar group tips, apparently as a unit, so that the long chromosome approaches the gap in the ring of thirteen autosomes. Eventually this whole group passes to the center of the ring and thus the two daughter-cells (second spermatocytes) receive respectively 14 and 21 chromosomes. Size relations and position facilitate the identification of homologous daughter chromosomes of the anaphase plates when these are observed superimposed within a single section (Figs. 4 and 6). Thus the thirteen autosomes of either daughter ring may be readily identified, and, by elimination, the fourteenth of one ring unmated in the other. This fourteenth chromosome must therefore be considered as a Y-chromosome mated by that member of the X-group, the long chromosome, which is first inserted into the gap of the one ring, corresponding to the space occupied by the fourteenth chromosome of the other. Side views of metaphase figures of this division (Fig. 3) show the Y-chromosome lying opposite one end of its longer mate to which it may be united. Fig. 3 is an optical section of such a group showing the Y, its long mate, six other elements of the X-group massed and undivided, surrounded by certain of the dividing autosomes. A cleft in the X-chromosomes indicating the line of division in the ensuing second spermatocyte division may often be observed in the anaphase stage of the first division (Fig. 8). The long chromosome splits lengthwise and usually the chromatin appears concentrated at either end of each half giving a quadrivalent appearance and suggesting a tendency to separate in two parts, one to remain the mate of the Y and the other to increase the number of those unmated.

From the foregoing it will be clear that the secondary spermato-

cyte divisions should be of two classes, one showing 21 chromosomes including the microsome, and the other 14. Examination of numerous metaphase plates has proved this in the clearest manner to be the case (Figs. 9 and 10). This condition may be compared with that in *Ascaris lumbricoides* in which the two classes of secondary spermatocyte cells show respectively 19 and 24 chromosomes, or with *Acholla multispinosa* in which the spermatids receive either 11 or 15 chromosomes.

Oogonial cells showing division figures have not been found but the constant presence of 21 chromosomes in the maturation divisions of the egg indicates most certainly that the diploid number in the female is 42. Metaphase and anaphase plates of the first oöcyte division repeatedly give the count of 21 chromosomes. Figs. 11 and 12 show two daughter plates found superimposed within a single section and each gives the count of 21 chromosomes including the microsome. Such an observation of the dividing microsome, together with its constant behavior as a member of the X-group in the spermatocyte cells, gives the conviction that this minute body is in reality a chromosome. The second oöcyte plates (Fig. 13) again reveal the expected count of 21 chromosomes of which one is the microsome. Side views of both oöcyte anaphases show a clean separation of daughter plates with no sign of lagging chromosomes, so conspicuous in the first spermatocyte division.

These results demonstrate that in *Ascaris incurva* there are formed two classes of spermatozoa, one bearing 21 chromosomes, the other 14 chromosomes; and they indicate that fertilization of the egg carrying 21 chromosomes by a spermatozoön of the first class gives rise to the females which have 42 chromosomes and by one of the second class to the males which have 35 chromosomes. This cycle of the chromosomes may be summarized in the following formulae in which the autosomes are designated as A and the sex chromosomes as X and Y.

Spermatozoa of Two Classes.		Egg.	Gamete.
13A + 8X	+	13A + 8X	= 26A + 16X = 42 (female).
13A + Y	+	13A + 8X	= 26A + 8X + Y = 35 (male).

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EXPLANATION OF PLATE.

All figures are drawn with a Zeiss 1.5 mm. apochromatic objective, a no. 18 compensating ocular and projected with camera-lucida to table level. Figures as here reproduced give a magnification of 3,000 diameters. Figs. 1, 2, 3, 7, 8, 11, 12, 13 are from material fixed in Gilson-Carnoy's fluid and Figs. 4, 5, 6, 9, 10 from material fixed in strong Flemming's fluid.

FIG. 1. Spermatogonial metaphase.

FIG. 2. First spermatocyte metaphase showing the XY group centrally located and surrounded by 13 autosomes.

FIG. 3. First spermatocyte metaphase. An optical section of a side view showing the Y-chromosome opposite the end of the long X-chromosome, six other X-elements and three pairs of dividing autosomes.

FIGS. 4, 5, 6. First spermatocyte anaphase. Figures are from one spindle; Fig. 4 showing upper ring of 13 autosomes and Y, Fig. 6 showing lower plate of 13 autosomes and gap opposite position of Y in Fig. 4, Fig. 5 showing the intervening X-element of 8 chromosomes.

FIG. 7. First spermatocyte anaphase. A side view of late stage showing daughter plates of autosomes and X-group viewed edgewise.

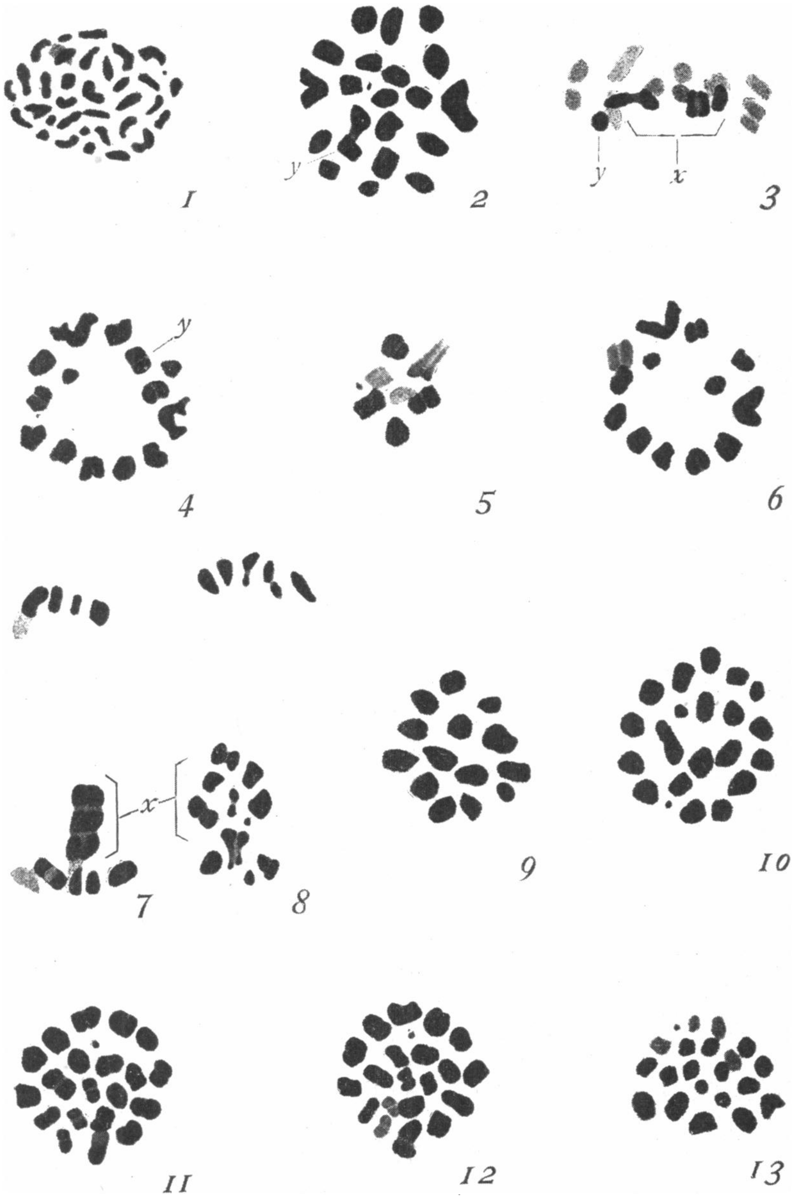
FIG. 8. First spermatogonial anaphase. Late stage showing 5 autosomes from upper plate, 3 from lower and the X-group of 8 chromosomes.

FIG. 9. Second spermatocyte metaphase showing 14 chromosomes.

FIG. 10. Second spermatocyte metaphase showing 21 chromosomes.

FIGS. 11, 12. First oocyte anaphase. Daughter plates from one spindle and each showing 21 chromosomes.

FIG. 13. Second oocyte metaphase showing 21 chromosomes.



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